

LATEST DEVELOPMENTS IN DIESEL LOCO

Modifications in ALCO/ DLW make locomotives have been done continuously to suit with the present operating criterion of the Indian Railways as well as to make it more reliable, maintenance free and economic. Although, there are many a modifications which have multiple benefits still they are broadly categorized under the following heads:

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- **FUEL EFFICIENCY**
- **OPERATING EFFICIENCY & RELIABILITY**
- **ENHANCEMENT OF MAINTENANCE INTERVAL**
- **UPGRADATION**

FUEL EFFICIENCY

1. Use of Fuel efficient kit

- **High efficiency turbo supercharger (NAPIER NA-295, ABB VTC-304)** to improve the rate of supercharging hence, combustion efficiency of the engine.
- **Larger Aftercooler with improved water piping** (water connection to Aftercooler has been given directly from RH Radiator) for better cooling of the charge air and improved flow rate. Hence volumetric efficiency of the engine improves, bettering the combustion efficiency.
- **17 mm FIP & modified FP Support** for sharper fuel Injection and thus improve IHP.
- **Modified cam shaft with 140° valve overlap** to improve scavenging towards better combustion efficiency.
- **Steel Cap Piston (Supported by high Lube Oil Pressure, 80 PSI)** to withstand higher compressive and thermal loading corresponding to higher peak firing pressure.

FEATURE IMPROVEMENT DUE TO INTRODUCTION OF FE KIT

FEATURE	WDM- 2	WDM-2 (FE)
Booster Pressure	1.4 bar	1.6 bar
Peak firing pressure	1400to 1600 psi	1650 to 1850 psi
Turbo inlet gas temperature	615±25°C	490±25°C
BSFC	166.7 gms/bhp.hr	156gms/bhp.hr

2. **Low Idle feature** It is noticed that most of the time due to improper communication locos continue idle run for hours. As such, good quantity of fuel is lost due to idle runs only. Low idle feature is aimed to reduce the fuel consumption by reducing the idle rpm. The lower critical speed of WDM2 Loco ranges from 350 to 450 rpm. Presently idle rpm of WDM2 loco is set at 400 rpm; hence there is scope for reducing idle rpm to 350. In low idle feature this has been introduced with the following modification.

- In the locos with Woodward Governor in Idle notch, none of the solenoid is energised to make 400 rpm. Each notch causes a change of 86 rpm to its corresponding notch with the engagement of solenoids in different combinations. The impact of different solenoids on engine rpm are as such :-
 A = +1×86 engine rpm.
 B = +4×86 engine rpm.
 C = +2×86 engine rpm.
 D = -2×86 engine rpm.

Hence to introduce low idle feature, A and D solenoids are energised in combination and thereby adjusting the engine to 340 rpm by adjusting other notch rpm within tolerance zone. It is a difficult process and need to repeat several times to set the desired rpm.

In addition to this, time delay setting of LOPS system need to be adjusted by setting the bypass valve to get operated from 3rd notch onwards as well as LOPS setting is also reduced to 1.3 to 1.1 kg/cm² according to the low engine rpm.

- In the second method idle rpm is directly started with 350 rpm without engaging any solenoid i.e. with the adjustment of leverage only. Engagement of solenoid will give speed variation of 93 rpm multiplied by their multiplication factor and thus 8th notch is maintained to 1000 rpm.
 Setting of bypass valve need not be changed and will be functional from 2nd notch onwards. LOPS setting will be reduced to 1.3 to 1.1 kg/cm² according to low engine rpm at idle notch.

3. **Cyclonic Air filter** This is to improve the flow rate of air in the air induction system. It consists of three panels in each side containing primary and secondary filter elements.

Primary elements consist of converging tubes with deflecting vanes at the entry. So that, the air during entry will be deflected into cyclonic motion inside the tube and thus due to rapid change in the direction the heavier dust particles gets separated and collected at the bottom container and finally thrown away to the atmosphere by motor driven blower. The clean air finally discharged through concentric narrow tubes and enters into secondary elements for fine filtration before entering into Turbo.

Secondary filter elements consist of either paper type filter element or pad type fibreglass element. Paper type element had maximum instances of catching fire; as such the latest elements are all made of fibreglass.

4. **AC-DC Transmission with single transition** In this, alternator is used instead of DC generator which gives AC output. Rectifier converts it into DC for giving input to DC traction motor. Suitable modification has also been made in excitation system to increase the Voltage limit up to 1100 V, so that, entire speed range can be covered by single transition only

Due to AC, generating efficiency has been improved with the considerable improvement in reliability. Moreover due to single transition, transition losses have also been reduced. This has an overall contribution towards fuel efficiency.

RELIABILITY & OPERATING EFFICIENCY

The following modifications have been carried out towards reliability and operating efficiency.

1. Modification pertaining to cooling water system

- **Pressurised cooling water system:-** Pressurized upto 7 psi with the help of providing a pressure and vacuum valve on the cap of expansion tank . Both the pressure and vacuum valves are set at 7 psi above and below atmospheric pressure, so that system is not stressed with excess pressure and vacuum (due condensation of steam).
-due to pressurization upto 7 psi boiling point of water raises by 11°C, this not only saves water due to boiling but also the heat dissipation rate across radiator improves due to higher temperature gradient.
- **Louvered Fin Radiator :-** Improves cooling efficiency by 14% due to improved air flow.
- **Mechanically Bonded Radiators:-** Mechanically bonded radiators are used to improve reliability and longer life of radiators. They are made of seamless tubes and bonded mechanically with the headers. The conventional radiators were made of rolled and soldered tubes and are soldered with the headers.
- **Revised ETS setting:-** Previously there were 3 ETSs. In which ETS 3 was set at 84°C as hot engine safety & alarm. When ETS got operated bringing the engine to Idle with hot engine alarm.
In the modified system an additional ETS is included with the change in setting like:-
ETS-3 is set at 90°C when hot engine alarm will ring only, giving indication to the driver about hot engine, so that driver can clear the block section and cool the engine by fast pumping, putting the GF switch off.
ETS-4 is set at 95°C. In this, the loco will come to idle automatically when driver fails to act according to ETS 3 indication.
- **Revised OPS setting** With the pressurized+ cooling water system the engine is allowed to run at elevated temperature. Hence to cope up with the reduced viscosity of lube the OPS setting is also revised as under:-
Previously 1.8 to 2.1 kg/cm²
Revised 1.3 kg/cm²

2. Design development of some of the major components:-

- **Development of larger thrust collar trilobe bearings in 720 A1 turbo.** With this, failure of bearings has been reduced and maintenance interval could be enhanced to half yearly schedule.
- **Introduction of high efficiency turbos** With the introduction of high efficiency turbos like Napier, ABB, GE, Hispano-Suiza etc both efficiency

and reliability has improved. They need inspection on yearly schedule and overhauling in 3 yearly or POH schedule.

- **Batteries with ceramic vent plug and level indicator** has increased the trouble free life of batteries.
- **251+ Cylinder head:** They are mainly used in uprated engines (suitable to use upto 3600 HP).

Features:-

- Fire deck thickness reduced.
- Middle deck modified by swooping it down in flying buttress fashion so that water flow inside jackets is unrestricted and streamlined as well as more water can be accommodated.
- Increased number of ribs (supports) between fire and middle deck to increase its mechanical strength.
- Number of cores (14 instead of 11)
- Use of frost core plugs instead of threaded plugs.
- Made lighter by 8 kgs (Al spacer is used to make good the gap between rubber grommet and cylinder head.)
- Retaining rings of valve seat inserts eliminated.

Benefits:-

- Better heat dissipation
- Failure reduced by eliminating sagging effect of fire deck area.

- **Turbocharger with twin After Cooler – in GE makes turbo.**

Benefits:-

- Lower intake air temperature
- Lower exhaust gas temperature, due to better combustion.
- More reliable, due to larger thrust area
- Time between overhauls 6 years, coincides with Loco overhauls.

- **Modified Steel Cap Piston (Single bolt / 4 bolt design)**

Benefits:-

- Cases of looseness of stretch bolts eliminated
- Leak past gases through the bolt holes eliminated.

- **Fuel Injection Tubes of ST 52.4 NBK materials. (Previously it was of AISI 4130 material)**

- Able to withstand higher pulsating pressures, especially on Fuel efficient / high HP locomotive.
- Failure rates reduced

- **Exhaust valves of Inconel material. (existing valve with 21.4 N material)**

- Improved mechanical strength at elevated temperature. (100 kg/mm² at 600°C, existing strength is 50 kg/mm² at 600°C)

- **Stiffer Unit Cam shaft**

Feature:-

- One segment for each cylinder, having air, fuel and exhaust cam
- Disregarding firing order two basic designs for cam, LH & RH
- Cam bearing areas are not contained in sections, they are in distant pieces.

- Distant pieces have cam bearing areas of same old dia, due to size limitation of bearing housing.
- Cam segments are connected to distant pieces through flange joint of same dimension as old.
- Unit cam shafts are fitted through sides without disturbing other cylinder
- Accessory elements like FP Support, PR Lifter, X-Head Lifter etc are need to be changed.

Benefits:-

- Meets the requirement of uprated engines, due to excessive wear rate of cam / roller.
- Easy to replace.

- **Centrifugal Lube oil cleaner (Lube Oil Centrifuge)**

- An additional filter, works under centrifugal action
- Connected in parallel (bypass circuit) to the main lube oil circuit.

Benefits:-

- Ensures more effective filtration with constant filtering efficiency.
- Longer oil change intervals
- Enhances life of paper filter.
- Overcome hindrance for 90 days schedule

- **Rack / Panel mounted brake**

- All the valves in brake system are mounted in close proximity on the panel
- Reduced piping. (No loose piping required for mounting valves)

Benefits: -

- Less chances of air leakage
- Easy trouble shooting and better maintenance.

- **Plate type Lube Oil Cooler**

- consists of alternate layers of thin and gasketed plates.
- Hot and cold fluids flow between alternate plates, offering better heat transfer.

Benefits :-(Test bed evaluation at RDSO)

- Heat rejection rate 295 KW against 190 KW with conventional shell and tube type cooler.
- Peak Oil temperature was within the permissible limit of 105°C even with the water jacket temperature of about 85°C.

- **Twin Tower type Regenerative Air Dryer**

- Each tower works alternately
- Desiccants once full of moisture automatically regenerates themselves.

Benefits:-

- Moisture free air, hence trouble free equipment (More reliable electro-pneumatic and pneumatic valves used in control and brake system).

-Maintenance free service, except replacement of dessicants after 18 months.

- **E-Beam Cable:-**

- State-of-the-art technology used in traction cables
- Better mechanical strength, higher insulation and can withstand higher temperature.
- Allows higher current in the same cross section
- Better resistance to oil and other contaminants. Hence longer life
- Will lead to considerable saving in copper and weight

ENHANCEMENT OF MAINTENACE INTERVAL

The following modifications are directed towards the enhancement of maintenance interval.

- **Lube oil**

- ◆ Enhanced sump capacity

	7 days	10 days	14 days
WDM2	Sump capacity: 910 ltrs. Consumable oil 240 ltrs.	Sump capacity 1070 ltrs. Consumable oil 400 ltrs (High mark enhanced by 2")	Sump capacity 1270 ltrs. Consumable oil 600 ltrs. (Sump redesigned)
WDG2	-	-	-do-

Consumption rate of lube oil ranges from 4.5 to 7.5 ltrs / 100 EKM. Calculation is based on average consumption of 7 ltrs / day with 450 EKM run per day.

- ◆ Oil free GD80 Filter

Conventional GD80 Filter uses oil for filtration. This has to be checked for contamination at every 15 days. The present design of paper filter element need to be changed after 90 days. They are now used in all new built ALCO locomotives.

- **Suspension bearing oil (Capacity enhancement)**

	WDM2 (CONV)	WDM2 (10 DAYS)	WDM2 (14 DAYS)	WDG2
TYPE OF T/MOTOR	165/165M	165M(Mod)	4906(Mod)	4906(Mod)
SUMP CAPACITY	6+2* ltrs	7.5+2* ltrs	9 ltrs	9 ltrs
CONS.	3+2* ltrs	4.5+2* ltrs	6 ltrs	6 ltrs

OIL				
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* Capacity enhanced by welding tube

Consumption rate of suspension bearing oil is 0.25 ltrs/ day for goods and it is higher for passenger train. Hence 6 ltrs consumable oil is good enough for 21 days schedule for goods train. However, passenger trains need to touch shed after 11-12 days.

- **Light weight Traction Motors with Roller Suspension Bearing**
 - Used in WDP2 and WDM3C locomotives
 - Lower unsprung mass and reduced axle load has increased speed potential for passenger locos and made them more track friendly.
 - More reliable and suitable for 90 days schedule.
- **TM 4907 with Roller Suspension Bearing**
 - Used in WDG2 and WDM2C locomotives
 - Reliable and suitable for 92 days schedule.
- **Expressor Oil**

	Sump capacity	Consumable oil
WDM2(CONV)	21 ltrs	4.5 ltrs
WDM2 (MOD)	30 ltrs	13.5 ltrs
WDG2(COMPR.)	21/20 ltrs	7 ltrs

No shortage upto 30 days schedule

- **Gear case compound**

	Capacity	Consumable
WDM2 (CONV)	6 kg	4.5 kg
WDM2 (MOD)	9.5 kg	8 kg
WDG2	9.5 kg	8 kg

- No shortage for 21 days schedule.
- Consumption rate 0.3 kg / day

- **Engine air intake filter**

- 7 days cleaning for air intake filter
- 21 days cleaning for inertial filter

- **Radiator Blowing**

- For louvered fin radiator air blowing needed in 30 days.
- 21 days schedule no problem.

**** Hindrance for 21 days schedule**

- Carbon brushes for small motors need attention in 7 / 10days.
- Car body filters need cleaning in 7 / 10days.

UPGRADATION OF ALCO LOCOMOTIVE

The upgradation of ALCO / DLW locomotive took place in the following stages:-

1st stage: -

- 16 cylinder, 2600 HP Locomotives were upgraded to 3100 HP Locomotives. They are WDM-2C, WDG-2, and WDP-2.
- 12 Cylinder, 1850 HP Locomotive was upgraded to 2300 HP Locomotive. i.e. WDP1.

2nd stage: -

- 3100 HP Locomotives are further aimed to upgrade to 3600 HP locomotive. They are under project stage.
- 2300 HP Locomotives are aimed to upgrade to 2700 Hp. (Project stage).

3100 HP LOCOMOTIVES

- WDM 2C, WDG 2 and WDP 2

• WDM-2C

This is the first version of upgraded Loco, used in mixed traffic. In this only engine is uprated, bogie and suspension system remained same as in WDM2 Loco.

Technology Input: -

- Use of FE kit as applied in 2600 HP fuel efficient loco.
- Use of cyclonic air filter.
- Use of high rated and high efficiency turbo supercharger.(ABB, Napier etc.)
- Use of Alternator (TA 10102 CW,BHEL make) instead of Generator (TG10931,BHEL make)
- Traction Motor same (4906 AZ)
- Use of rectifier, either BHEL make or imported (Canada make)
- FTMB of higher capacity (12000 cfm delivery), to meet requirement of extra air for cooling rectifier.
- Excitation Control – E type, with suitable modification for high voltage rating for single transition system.
- 450 AH Pb Acid Battery with Ceramic vent plug and level indicator.
- Radiator of higher surface area with louvered fin.(Length enhanced by 15" and height by 3").
- Under frame:- light, fabricated with detachable fuel of 6000 ltrs capacity.
- Drivers' cab :-Redesigned with drivers seat on LHS of Cab in short hood leading position and assistant drivers seat diagonally opposite to Driver's seat.
- Panel mounted brake (IRAB-1) for easy maintenance and less trouble.
- Co-Co Tri-mount bogie, sand boxes mounted on bogie.

Operational parameter

	WDM2	WDM2C
(a) Engine gross HP	2600	3100
(b) HP input to Traction	2250	2750
(c) Rated Engine speed	1000	1050
(d) Min cont. rated speed (kmph)	18	22.8
(e) Continuous rated TE (Tons)	24.6	28.5

Benefits derived over existing WDM2 loco

- (a) Saving in fuel consumption by 6 %
- (b) Reduction in Lube oil consumption by 10 %
- (c) Reduction in maintenance cost
 - due to enhanced life of components for reduced EXHT. gas temperature.
 - Trip Schedule interval changed from 7 to 10 days.

Haulage Capacity

	WDM2	WDM2C
(a) Passenger Coach	17 (with 2 AC)	22 (With 1 AC)
(b) Freight	Bal speed 59 kmph with 4700 T BOXN	Bal. Speed 69 kmph. with 4700 T BOXN

• **WDG 2**

Upgraded (3100 HP) goods version ALCO/DLW Locomotive.

Engine portion of this Locomotive is almost similar to WDM 2C Locomotive except a few changes in latest locomotive, like use of GE Turbo with twin Aftercooler, 251+ cylinder head etc. But the bogie and suspension system has major changes to meet the requirement of goods traffic with higher tractive effort, as follows:

- Two stage suspension
Primary : Helical springs between axle and bogie with hydraulic damper.
Secondary: Compressed rubber springs (4 Nos. in each bogie) between bogie and chassis with hydraulic Yaw damper.
- Weight transfer through side bearers (compressed rubber spring) only
- Centre pivot free from load sharing, except transmitting tractive effort and braking effort.
- Bogie fabricated with unidirectional Traction motor (LLL/RRR), to improve adhesion.

- Increased axle load (20.5 tons) due to enhanced gross weight (123 tons) of the locomotive, improves adhesion.
- Gear ratio (74:18), mechanical assistance to enhance tractive effort.

Performance Indices

	WDM2	WDG2
Starting TE	30.4 tons	37.8 tons
Starting Load	4700 tons(on level track) 2940 tons (1:200 gradient) 2510 tons (1:150)	4700 tons (1:300 gradient) 3766 tons (1:200 gradient) 3185 tons (1:150)
Balanced Speed	59 kmph on level	69 kmph on level

- **WDP2**

Upgraded (3100 hp) Passenger version ALCO/DLW Locomotive.

- Similar to WDG2 locomotive except some difference in bogie and suspension system
- Driver's Cab is provided at both ends of the locomotive.

Bogie Feature

- Flexicoil Mk-V bogie. Both primary and secondary suspension are having helicoil springs.
- Having low flange resistance and speed potential upto 160 kmph.
- Sharpest curve to negotiate: 175 m. radius.
- Gear ratio 22:61
- Max TE at start 29100 kg.
- Continuous rating : 21523 kg TE at 29.7 kmph speed (new wheel).

- **WDP1**

Upgraded (2300 HP) version of ALCO 12 cylinder engine, used in passenger traffic.

Technical/ Operating Parameter:

- HP 2300/2150
- ENGINE RPM 1000
- TURBO VTC-304-WG06
NA-295-520
- ALTERNATOR TA 10106 AZ
- MOTOR ARRANGEMENT 4P FF
4P PF (49% FF)
- RADIATOR 43000 BTU/MIN
- FTMB 12000 CFM CAPACITY

- BRAKE 28 LAV1 Panel mounted equipped with Tread Brake Unit.
- AIR FILTRATION CYCLONIC
- FUEL TANK Detachable, 3000 ltrs. capacity.
- CAB LAYOUT One side Cab, having control desk location with driver's seat LH drive.
- BOGIE FLEXI COIL, Sand Box mounted on bogie.
- LOCO WEIGHT 80 Tons.
- WHEEL ARRANGEMENT BO-BO
- MAX AXLE LOAD 20 Tons
- GEAR RATIO 18:65
- MAX OPERATING SPEED 120 kmph
- MAX T.E. AT START 20 000 KG
- CONT. RATING 16400 KG at 29 kmph.
- MU OPERATION Max 3 Units (also with WDM2 loco).

Capability comparison of passenger locos:

* SPEED	WDM2	WDM2C	WDP2	WDP1
100 kmph.	17	22	23	17
120 "	10	13	15	11
140 "	-	-	10	7/8

* Calculation is based upon coach weight of 45 Tons (Non AC)